a three-dimensional expanded form. Although similar to conventional wire mesh screens, these materials are made from a single thin sheet by punching an array of holes while pulling the material. In the flattened form the holes are an array of diamonds. In the expanded form, the filaments are in a regular tetrahedral configuration. These materials can be made in thicknesses as small as about 0.0015 inch (1.5 mil) and from a variety of metals, including copper, aluminum and nickel.

[0162] Fresnel lenses may be used as the wicking material. Wicks that have microchannels having depths of less than about 100 microns, and in one embodiment about 50 to about 100 microns may be used to promote rapid mass transfer.

[0163] The wicking region may be prepared by laser machining grooves into a ceramic tape in the green state. These wicks can be made, for example, with grooves less than 50 microns deep with openings less than 100 microns wide. These grooves typically have a rectangular shape. Ceramic wicks have a high surface energy, are chemically inert, and have high temperature stability. Another material that may be used is an intermetallic formed from two or more metals placed in intimate contact during a bonding process and which combine to form an alloy, compound, or metal solution. Useful intermetallics have properties similar to the ceramic materials. An advantage of engineered structures is fine control of the length-scale for mass transfer in the liquid phase which is desirable for distillation.

[0164] In one embodiment, the wicking region may not be permitted to dry out during operation since this could result in vapor escaping through the wicking region. One approach to avoid vapor intrusion into the wicking region may be to add a flow restriction in capillary contact with the wick structure entrance, such as a porous structure with a smaller pore size than the wick structure and limiting the magnitude of the suction pressure such that the non-wetting phase(s) cannot displace the wetting phase from the flow restriction. This type of flow restriction may be referred to as a pore throat. In one embodiment, a pore throat may be provided between the wicking region and the liquid outlets (e.g., **454**, **674**) and/or liquid inlets (eg., **456**, **676**).

[0165] A heat exchanger may be used for cooling, heating or both cooling and heating. The heat exchanger may comprise one or more heat exchange channels, electric heating elements, resistance heaters and/or non-fluid cooling elements. These may be adjacent to the process microchannels. In one embodiment, the heat exchanger may not be in contact with or adjacent to the process microchannels, but rather may be remote from the process microchannels. In one embodiment, the heat exchanger may exchange heat with some but not all of the process microchannels. In one embodiment, the heat exchanger may exchange heat with some but not all of the microchannel distillation sections. In one embodiment, a single heat exchange channel may be used to heat or cool two or more, for example, two, three, four, five, six, eight, ten, twenty, etc., process microchannels. The electric heating element, resistance heater and/or non-fluid cooling element may be used to form one or more walls of the process microchannels. The electric heating element, resistance heater and/or non-fluid cooling element may be built into one or more walls of the process microchannels. The electric heating elements and/or resistance heaters may be thin sheets, rods, wires, discs or structures of other shapes embedded in the walls of the process microchannels. The electric heating elements and/or resistance heaters may be in the form of foil or wire adhered to the process microchannel walls, liquid channel walls, and/or vapor channel walls. Heating and/or cooling may be effected using Peltier-type thermoelectric cooling and/or heating elements. Multiple heating and/or cooling zones may be employed along the length of the process microchannels. Similarly, multiple heat exchange fluids at different temperatures may be employed along the length of the process microchannels. The heat exchanger may be used to provide precise temperature control within the process microchannels. The heat exchanger may be used to provide a different operating temperature for each microchannel distillation section.

[0166] Cooling and/or heating elements in the heat exchange channels may be used to provide varying temperatures along the length of the microchannel distillation units. This is illustrated in **FIGS. 29-31**. These figures show various embodiments for cooling and/or heating the microchannel distillation columns or apparatuses, for example, the columns or apparatuses **210** illustrated in **FIGS. 2, 3** and **12**. These cooling and/or heating elements are also applicable to the other microchannel distillation units disclosed herein. The cooling and/or heating elements may be in the form of separate heating and/or cooling (e.g., refrigerant) loops **215** (**FIG. 29**), loops using the outlets of other loops **215***a* as feed (**FIG. 30**), and/or nested loops **215***b* (**FIG. 31**).

[0167] The heat exchange channels may be microchannels although they may have larger dimensions that would not characterize them as microchannels. Each of the heat exchange channels may have an internal dimension of height or width of up to about 10 mm, and in one embodiment about 0.05 to about 10 mm, and in one embodiment about 0.05 to about 5 mm, and in one embodiment from about 0.05 to about 2 mm, and in one embodiment from about 0.5 to about 1 mm. The other internal dimension may be of any value, for example, from about 1 mm to about 50 cm, and in one embodiment about 1 mm to about 10 cm, and in one embodiment about 5 mm to about 5 cm. The length of the heat exchange channels may be of any value, for example, from about 5 mm to about 200 cm, and in one embodiment about 1 cm to about 200 cm, and in one embodiment about 1 cm to about 50 cm, and in one embodiment about 2 cm to about 10 cm. The separation between each process microchannel or liquid channel or vapor channel and the next adjacent heat exchange channel may range from about 0.05 mm to about 5 mm, and in one embodiment about 0.2 mm to about 2 mm.

[0168] The microchannel distillation columns or apparatuses (e.g., **110**, **210**, **310**) may have rectangular cross sections and be aligned in side-by-side vertically oriented interleaved planes or horizontally oriented interleaved stacked planes. These planes can be tilted at an inclined angle from the horizontal. These configurations may be referred to as parallel plate configurations. An array of these rectangular channels can be easily arranged in a compact unit for scale-up.

[0169] The flow rate of the vapor phase flowing through the microchannel distillation units may be in the range from about 0.001 to about 10,000 liters per minute (lpm), and in